LETTER

REPLY TO PIERRET AND LACOMBE:

Global controls on maximum rooting depths remain important

Ying Fan[a,1], Gonzalo Miguez-Macho[b], Esteban G. Jobbágy[c], Robert B. Jackson[d,e,f], and Carlos Otero-Casal[b]

We appreciate the comments by Pierret and Lacombe (1), highlighting the enormous complexity and observational challenges in root–environment relations. This challenge is evident in the scatter presented in figure 3 of our paper (2). Regarding water table depths in particular, Pierret and Lacombe (1) correctly point out that there are rooting depths below the water table in our figure 3*F*. However, the vast majority of these cases are for shallow water tables, mostly <1 m deep. Such cases are more likely to have water tables that are temporarily shallow or where the groundwater is oxygenated. Deeper than 1 m, the water table appears to provide a strong constraint on rooting depth (2). Elucidating such controls on deep rooting was the goal of our paper; we believe the relationship we identified between the depths of maximum rooting and the water table is robust.

There is value in simplifying rooting relationships and identifying the environmental controls and feedbacks on them. For example, emerging first-order patterns, drivers, and interactions are needed to inform earth system models (ESMs) of global change. It is widely acknowledged that plant rooting depths play a critical role in ecosystem functioning and water, carbon, and nutrient cycling, but many current ESMs prescribe fixed rooting depths based on plant functional types. Interactions between factors such as water table depth and bedrock clearly constrain rooting depth in many cases.

The exceptions to the rule are important to study, as well. As Pierret and Lacombe (1) point out, there are individual plants whose roots extend below the water table (our figures 3*F* and S6). We carefully included these data points in our analyses. Pierret and Lacombe (1) also suggest that there is likely an "observer-expectancy bias" in general, as they and colleagues have discussed in previous publications (3, 4). We agree this bias is real, because most observers do not search for the maximum rooting depth of a given ecosystem. Nonetheless, we believe our central hypothesis is correct—that land drainage plays an important role in helping to predict rooting depths locally and globally. Its central importance has been overlooked in many previous studies where climate, soil, and plant factors were primarily considered. In compiling the observations, we included all studies, most of which did not mention the water table. It is also important to point out that such interactions are bidirectional; plants alter the depth of the water table as well as respond to it (5).

In summary, if the outcome of our paper and the comments by Pierret and Lacombe (1) is to increase real observations of water tables and deep roots (6–9), then everyone will benefit. We thank them for highlighting the complexities of the problem and for their past synthesis work (3, 4).

1 Pierret A, Lacombe G (2018) Hydrologic regulation of plant rooting depth: Breakthrough or observational conundrum? *Proc Natl Acad Sci USA* 115:E2669–E2670.

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5 Nosetto MD, Jobbágy EG, Jackson RB, Sznaider GA (2009) Reciprocal influence between crops and shallow ground water in sandy landscapes of the inland Pampas. *Field Crops Res* 113:138–148.

6 Freeze RA, Cherry JA (1979) *Groundwater* (Prentice-Hall, Englewood Cliffs, NJ).

[a]Department of Earth and Planetary Sciences, Rutgers University, New Brunswick, NJ 08854; [b]Non-Linear Physics Group, Faculty of Physics, Universidade de Santiago de Compostela, E-15782 Santiago de Compostela, Galicia, Spain; [c]Grupo de Estudios Ambientales–Instituto de Matemática Aplicada San Luis, Consejo Nacional de Investigaciones Científicas y Técnicas, Universidad Nacional de San Luis, D5700HHW San Luis, Argentina; [d]Department of Earth System Science, Stanford University, Stanford, CA 94305; [e]Woods Institute for the Environment, Stanford University, Stanford, CA 94305; and [f]Precourt Institute for Energy, Stanford University, Stanford, CA 94305

Author contributions: Y.F., G.M.-M., E.G.J., R.B.J., and C.O.-C. designed research; and Y.F., G.M.-M., E.G.J., and R.B.J. wrote the paper.

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[1]To whom correspondence should be addressed. Email: yingfan@eps.rutgers.edu.

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